Determination and Evaluation of Web Accessibility

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Abstract

The Web is the most pervasive collaborative technology in widespread use today; however, access to the web and its many applications cannot be taken for granted. Web accessibility encompasses a variety of concerns ranging from societal, political, and economic to individual, physical, and intellectual through to the purely technical. Thus, there are many perspectives from which web accessibility can be understood and evaluated. In order to discuss these concerns and to gain a better understanding of web accessibility, an accessibility framework is proposed using as its base a layered evaluation framework from Computer Supported Co-operative Work research and the ISO standard, ISO/IEC 9126 on software quality. The former is employed in recognition of the collaborative nature of the web and its importance in facilitating communication. The latter is employed to refine and extend the technical issues and to highlight the need for considering accessibility from the viewpoint of the web developer and maintainer as well as the web user. A technically inaccessible web is unlikely to be evolved over time. A final goal of the accessibility framework is to provide web developers and maintainers with a practical basis for considering web accessibility through the development of a set of accessibility factors associated with each identified layer.

Keywords: Accessibility; evaluation framework; accessibility legislation, standards, and guidelines.

1. Background

The development of computers and their application in information systems in the middle of the 20th century brought novel developments in the representation of information such as Bush's Memex [1], an early pre-cursor of hypertext. Later the concept of hypertext was more fully developed by Nelson and others, see Conklin [2].

From the initial concepts of the Memex and hypertext, support for collaboration as well as universal accessibility have been key design objectives. Bush distinguished between material accessibility and intellectual accessibility [1]. He recognised that current mechanisms for recording and accessing information were largely physical depending upon our senses of touch, speech, hearing and vision without precluding the possibility of a more direct means of communication and access in the future. More importantly, he recognised the need for humans not only to add to the record of human knowledge, but also to make the basis of their reasoning explicit. Without any indication of rationale and explicit linking of recorded knowledge, intellectual progress is held back. While material accessibility is obviously necessary to support collaboration, true collaboration requires intellectual accessibility as well. Therefore, designers of collaborative technology should give consideration to both.

Nelson's Xanadu project of the 1960s sought to establish a universal, democratic hypertext library that would help human life evolve into an entirely new form [3]. It cannot be denied that developments such as hypertext have bought more flexibility to the representation of information, but that they fell short in achieving universality, particularly in terms of accessibility.

More recently with the development of the World Wide Web, Bush's vision of a medium whereby bodies of human knowledge could be explicitly linked to reflect their foundations has become a reality. One of the key design concepts underpinning the web is that it is a "space" in which information exists and can be collectively extended and shared [4]. Viewed as a large shared information space, the web is the most pervasive collaboration technology in the world today. Technically in the development of the web, Berners-Lee sought to overcome the practical communication barriers to information exchange in the form of incompatibilities between different computer systems through the development of a common hypertext representation, html, a common communication protocol, http, and a means of uniquely identifying information resources, the url [4].

His solutions whilst overcoming technical barriers to computer to computer communication have left open the problem of overcoming the human to human communication barriers resulting from limits to physical and intellectual access. It is clear that these too have been an overriding concern to Berners-Lee as the following quote indicates: *"The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect."* [Tim Berners-Lee, opening quote on www.w3.org/WAI/].

The extent of the accessibility problem can be gauged from the W3C estimate that more than 90% of sites on the WWW today are inaccessible to disabled users [5]. As the web becomes more and more intertwined within the fabric of our society and the support for collaboration originally envisaged by its pioneering developers is evolved, the need for consideration to be given to web accessibility is crucial if it is to be truly universally accessible.

In the remainder of this paper, the discussion will focus on the determination and evaluation of web accessibility within the broad perspective that views the web and its associated applications as exemplars of collaborative technology.

2. Aspects of Accessibility and Evaluation Layers

Given the collaborative nature of many web-based systems, and the role that the web plays in providing a world-wide shared information space, accessibility is a key design issue. A layered framework can provide a way of understanding accessibility from many perspectives and for evaluating web-based systems as CSCW systems with respect to their accessibility. The framework presented here originally derives from Ramage[6] where it is described as a first step towards a heuristic method for CSCW evaluation [7]. It is presented in two ways, as a diagram which shows the inter-dependency of the issues involved, specifically that (after the style of the 'systems hierarchies' discussed by Checkland [8]) the 'higher' evaluation criteria are dependent for their effectiveness on the 'lower' ones, and as set of questions. The diagram is expressed in a series of concentric circles, which gives the framework its informal name, *Ramagian Onion* (see Figure 1).

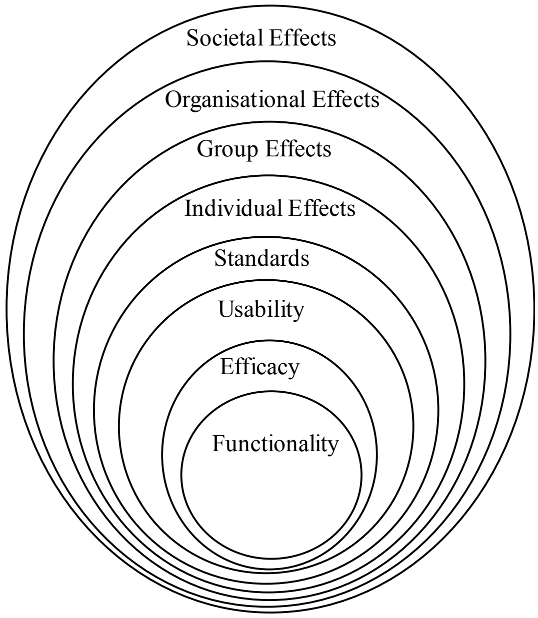

Figure 1: The layered model of CSCW evaluation (taken from Ramage [6])

The eight layers here can be expressed as a set of questions (going from the inner layer out), which can be asked about a CSCW system. Ramage's associated questions are as follows:

1. Does it work? *(functionality)*
2. Does it work well enough? *(efficacy)*
3. Is it workable with? *(usability)*
4. Does it follow the *standards* laid down by various bodies?
5. What does it do to those who work with it? *(individual effects)*
6. What does it do to their work? *(group effects)*
7. What does it do to those they work with and for? *(organisational effects)*
8. What does it do to the world beyond work? *(societal effects)*

The four inner layers of the framework are concerned with technical issues while the four outer layers are more concerned with social issues. From the technical standpoint, the framework can usefully be broadened to encompass the following quality characteristics taken from the ISO/IEC Product Quality Standard [9]: Reliability, Efficiency, and Maintainability. These can be layered as follows in Figure 2 with the four outer layers as before.

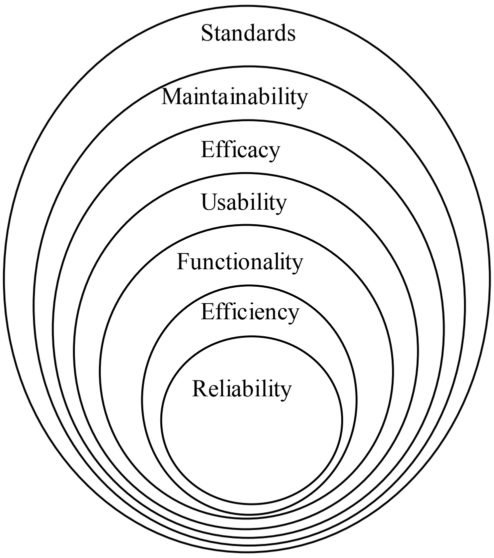

Figure 2: Extended Inner Layers

If a system is neither reliable nor efficient, it will be difficult to determine its functionality. There must be a sound engineering basis at the heart of any collaboration technology to ensure its continuing accessibility over time. Following the standard, these quality characteristics can be broken down into more measurable factors. In the case of reliability, the factors identified are maturity, fault tolerance, and recoverability. In the case of efficiency, they are time behaviour and resource behaviour.

The factors associated with functionality in the standard are suitability, accuracy, inter-operability, compliance, and security. For the purposes of evaluation in this context, it seems useful to focus on accuracy and seek to determine whether or not the system functions as specified, leaving considerations of suitability to be considered under the heading of efficacy. Efficacy can only be determined by dynamic analysis of use and is closely linked with usability. The standard associates three factors with usability: understandability, learnability and operability. All of which would also entail studies of users. Evaluation here thus requires the co-operation of users; it will in part be subjective in nature. Nevertheless, there are aspects of physical accessibility, which can be considered here that admit to objective measurement. For example, the range of colours used in an application that are outside those recommended as web safe can be determined automatically.

The sixth technical layer, maintainability, addresses accessibility over time as a technically inaccessible system is likely to prove difficult to maintain and evolve throughout its lifetime. Factors associated with maintainability are analysability, changability, stability, and testability. Those associated in the standard with portatbility are also relevant here: adaptability, installability, and replaceability. The conformance factor concerned with the adherence of the system to standards is more relevant at the next layer, as are the compliance and interoperability factors listed in the standard under the functionality characteristic.

Under the standards layer, various standards as well as legislation and guidelines are relevant. Recent legislation relevant to the accessibility includes the USA Rehabilitation Act's Section 508, 1194.22 – also known as the American Disabilities Act [10], covering federal workplaces and Web sites, and various other national initiatives such as the UK Disability Discrimination Act [11]. A number of guidelines and standards are relevant to accessibility. Two most notable are World Wide Web Consortium's (W3C) Web Accessibility Initiative (WAI) Web Content Accessibility Guidelines [12] and the IEEE Std 2001–1999 [13]. Both of these have been subject to recent work. The W3C WAI guidelines have also have been developed and a new draft version of these, 2.0 [14], was released in 2001. The IEEE 2001 Web Site Engineering Recommended Practices [15] expected to be approved in 2002 is a revision of the 1999 standard with updates to align it with the recent USA section 508 legislation. Other guidelines focus on specific aspects of accessibility such as the UK Mencap's guidelines [16].

Ensuring compliance with these various standards and guidelines is likely to involve remedial maintenance work on many systems; and therefore maintainability is an important characteristic. Evaluating maintainability has been addressed with work on hypertext [17] as well as through specific studies of web evolution [18].

World-Wide Web maintenance is of increasing importance [19]. The WWW is growing rapidly and is being used more and more as an important medium for communicating information and as the basis for providing communication and information based services. Unfortunately so far people have attached far more importance to developing technology to add more and more novel features within Web sites rather than developing and maintaining sites of quality. There is currently very little work being done to systematically address the growing maintenance required for ensuring the Web continues to provide useful information and communication based services in a timely fashion. Without the disciplined application of change management and other maintenance practices well established in software engineering, this problem is likely to remain. Thus, evaluation of this characteristic involves examination of the maintenance processes as well as the system itself [20].

One aspect of this identified by Lowe is the need for more accessible web development processes [21]. Given the collaborative nature of much web development, having a defined and well understood development process is likely to bring all the associated benefits of software process improvement as advocated in traditional software engineering. However, it must be recognised that web development processes do not necessarily follow the same patterns as those of traditional software development.

On a micro level, Kaplan has argued that web technologies themselves, particularly mark-up languages and their underlying interpretation or execution models, must be made more accessible to developers and maintainers as well as users [22].

While accessibility is relevant at every layer, it is the technical layers that admit to more rigorous quantitative evaluation. For example, with respect to reliability, it is possible to determine the availability of a web-based application over any given period of time through straightforward measurement. The outer four layers largely must be determined qualitatively and often involve legal and political issues. Nevertheless, they must not be ignored in any accessibility evaluation.

When developing and enhancing web-based applications, there is often a primary emphasis on determining the technical feasibility. While this is understandable when working with new technologies in innovative applications, without consideration being given to the higher layers, it is likely that these novel applications will fail to support the collaboration needs that gave rise to their development in the first place. There is, of course, a tension here as novel CSCW systems are typical of Lehman's classic e-type, evolutionary systems, which once installed in their environment are bound to cause changes to way people do things [23]. So it is difficult to determine these broader social aspects except by reflection and envisioning possible future worlds before building the system and deploying it, but this is a key aspect of engineering – top down, to consider the social implications of new developments. However, given the evolutionary nature of these systems, evaluation must extend through to the system in use and over time, particularly with respect to its impact at the outer four layers, as well as standards, maintainability, efficacy, and usability. It is here that evaluation during use within specific contexts is essential.

Usability is a key aspect within the evaluation framework. A system may meet all its technical requirements. It may appear to fit within the individual, group, organisational, and societal needs, but unless it is usable in practice by its intended users, be they, individuals, groups, organisations, or society in general, it will fail. Nor can the effects of a system be determined at the higher layers without examining the system in various contexts of use over time. Bevan has argued with respect to measuring software quality that it is necessary to distinguish three types of measures: internal measures and external measures of software quality, basically related to static and dynamic properties of software, and measures related to the effects of the software product in various contexts of usage [24]. He argues that measurement at all three levels is required, and that internal quality influences external quality which in turn influences quality in use while quality in use depends on external quality which depends on internal quality. Higher layer evaluation is possible within a specific collaborative enterprise through considering usability with respect to a specific user population's characteristics and contextualising the higher layers' effects that the enterprise may seek to achieve in usage.

Usability in general is a topic that has recently received much attention, particularly with respect to web-based applications [25]. Usability in this context includes physical accessibility. Recently the usability needs of disabled users have been addressed directly, e.g. see [26, 27]. Coming to evaluation via the middle way of usability/accessibility in the wider context discussed here may prove most appropriate for web based collaborative applications, particularly those information systems focused on delivery of services and information to society as a whole.

Given the link between usability and maintainability found in Lehman's first law of software evolution [28], it is obvious that an unmaintainable system will become progressively less useful over time. Hence, the importance of maintainability in this context must also be recognised.

3. The Role of Tools in Evaluation, Repair, and Evolution

Various tools exist to determine whether or not a web site adheres to various accessibility and usability standards. Such tools can provide useful feedback to Web developers and maintainers, and many assist with the repair of the site. The best known of these tools, the Center for Applied Special Technology's Bobby [29], will analyse a site for conformance to the World Wide Web Consortium's (W3C) Web Accessibility Initiative (WAI) Web Content Accessibility Guidelines. Other publicly available tools providing a similar service include A(ccessibility)-Prompt [30], the result of a joint project between the Adaptive Technology Resource Centre at the University of Toronto and the Trace Center at the university of Wisconsin and NIST's WebSAT. The WebSAT tool set [31] checks conformance to usability guidelines found in the IEEE Std 2001–1999.

A growing number of commercially available tools and services have also come onto the market in part driven by the recent 508 legislation. These include the following: HiSoft's Acc{Repair, Verify, and Monitor} [32], PageScreamer [33], {Site, Page, Link, Form} Valet [34], UsableNet's Lift Online and Onsite [35], and SSB Technology's InFocus [36]. By integration with web development tools, these tools have been made more accessible to web developers. HiSoft's AccRepair/Verify/Monitor are integrated with the popular web development tool, Front Page. The Lift tools have been integrated within Dreamweaver, another popular web development system allowing users to check accessibility in much the same way as using a spell checker within a word processor. The checker covers Section 508 and level 1 W3C guidelines.

The effect of legislation on the development of these evaluation tools and accessibility initiatives is noteworthy. In practical terms, it is also the case that having a means of automatically checking conformance to legislation, standards, and guidelines, is bound to be a factor in their successful adoption and implementation.

Furthermore, accessibility evaluation can be a driver of evolution. Where accessibility has not be designed in from the start, re-engineering will be required to achieve a more accessible web site; and as noted below, this is likely to result in a more efficient and maintainable site in the future.

It has been argued that there is strong business case for re-engineering web applications to achieve accessibility. For example, one W3C working group has stated that

" Conformance with the WCAG 1.0 (and other W3C) guidelines will enhance the market share and audience reach of your Web site by increasing its general usability. Adoption of WCAG 1.0 recommendations also demonstrates your commitment to social responsibility and equity of access to information and services. In addition, many of the WCAG 1.0 checkpoints will directly improve the performance of your Web services and reduce the maintenance effort required." [37].

The first step to re-engineering web pages and applications for accessibility is to apply the classic techniques of program comprehension, static and dynamic analysis [19]. Considerable redevelopment of existing pages may be necessary; some tools can help [38], and services are on offer [39]. It is also important to ensure conformance with the relevant standards, guidelines, legislation, and tools covering these aspects have been noted in Section 3.

4. The Future

Accessibility is a pre-condition that must be satisfied before any technology can be deemed truly to support collaboration without any barriers. Universal accessibility remains a dream; and may not be achievable within the limitations of our current collaboration technology employed over the web. By attempting to determine the basis for evaluating accessibility and recognising both the technical and social challenges, the foundation for more focused work to ensure that in the future collaborative technology will more accessible in every sense of the word has been laid. The dimensions of accessibility go far beyond the simplistic design goal of "user-friendliness" and extend to web developers and maintainers as well as users. Not only does the web and its associated technology facilitate communication and collaboration amongst its users, its development and maintenance is usually undertaken as a collaborative activity involving teams distributed over a number of sites, so this means that accessibility is relevant with respect to web maintainability as well. A final goal of the accessibility framework developed here is to provide such teams with a practical basis for considering web accessibility throughout the lifetime of any evolving system.

There is a wealth of accessibility resources, but there is a long way to go before accessibility becomes a non-issue and is taken for granted by users and developers of collaborative technology. Accessibility is as much as technical issue as a social issue. Without attention to accessibility, the evolution of the web-based collaboration technology will fail to gain the necessary popular support needed to underwrite further research in this area. The framework presented here has been developed to provide a starting point for evaluation in this context.

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